Performance Report -- UVI Online Search Tool (UVI-OST)

Title of Grant:	A Climatological Database of Auroral Images for Solar Cycle 23: An Online Synoptic Search and Metadata Visualization Tool
Type of Report:	Annual Performance Report
Principal Investigator:	G. A. Germany
Period Covered:	5/1/2002 - 4/30/2003
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Summary of research objectives and plan

The primary goal of the funded work is to provide an online search and visualization tool of auroral and geophysical metadata covering the ascending phase of the current solar cycle. Prior to this program, there were no tools available for searches of auroral features or for visualization of derived parameters such as boundaries, energy input, or presence of given auroral morphologies. The lack of such tools meant that the vast majority of current research using auroral images is event-driven, where the only search criteria is the time of the event. The logistical difficulties of organizing synoptic studies spanning extended times, or of finding particular auroral morphologies regardless of the time of their occurrence, is one of the primary impediments for performing non-event-driven auroral studies.

In the second year of this research the following tasks were scheduled.

- Complete development of image metadata miners.
- Begin processing image metadata.
- Develop online interfaces for image metadata.

Most important results during report period

1. A new task was added to provide thumbnail images of the auroral images in the query result. This also included providing a link to the official UVI online data product.

2. A new task was added to remove background records from the database.

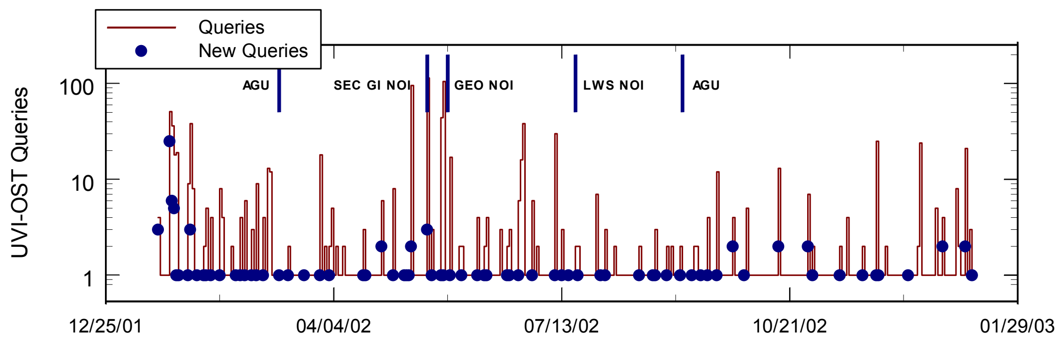
3. A new task was added to enable queries based on ground stations.

4. We began development of image miners.

5. We presented a paper at the Fall AGU meeting illustrating the scientific valid of databased image metadata.

General summary of performance

Since going online in January 2002, OST has been steadily used by the scientific community. The chart below summarizes the usage to date. Through 1/11/02, there were a total of 1056 queries from 119 unique IP addresses. Of particular interest is the fact that the usage (red histogram) seems to peak near proposal and meeting deadlines (blue reference lines). Also, queries from new users (blue filled circles) continue to be seen on a regular basis.



The principal emphasis of the second year of work was on the development of the image miner routines to automatically extract information from UVI images. A secondary emphasis was to add enhancements to the original database design that became apparent during algorithm development. Finally, the utility of the OST database for scientific study was presented in a paper at the Fall AGU meeting.

The enhancements will be discussed first. One of the key elements of the original OST design was that it enabled user queries on UVI metadata only. Metadata can include instrument configuration, spacecraft location, and field-of-view considerations. Later in the program, the metadata will be expanded to include image-derived information, such as boundaries, areas, and integrated intensities. The result of the query was a list of times that matched the search criteria. It was up to the user to use this list to request UVI data from a team member or other source. The key point is that OST was not responsible for delivering a data product, other than the metadata query result.

The main difficulty with this approach was that there was no way of easily evaluating the quality of the requested data. This could be quickly evaluated by visual inspection of UVI images, but OST didn’t supply that information. Therefore, we decided to provide links from the user query result page to online images maintained by the UVI science team. The online images constitute the official UVI data product and are available to all users. Adding this link allowed the user to judge the quality of the UVI data. However, the interface was awkward since the user had to follow a web link for every record in the query result.

Therefore we decided to added thumbnail images directly to the query result page. This required preprocessing every record to generate the thumbnail image, storing the images on the web server, and then adding the filename of each thumbnail to the OST database. Since the preprocessing algorithm structure had to be in place for the image miner development, this didn’t represent a great departure from our original plans.

This enhancement is a great success. The user can quickly judge the quality of the selected data simply by scrolling in the web browser.

During the thumbnail development, we noticed that many database records corresponded to the UVI background filter position. This wasn’t a problem originally, since we didn’t report filter information. (We store one record every 10 minutes, but UVI creates a record every 37 seconds. It was felt that reporting filter information would be misleading since the filter at the time sampled by the database was somewhat random.) The use of thumbnails, however, meant we had to be more careful in our selection of records for the OST database. A new database was thus constructed that included background records only if they were the only available filter during the ten minute period.

As part of our initial image miner development (discussed below) we paid particular attention to the location of the UVI field of view. It soon became clear that the ability to ask if a ground station was in the UVI field of view would be valuable. This was confirmed by OST users who we contacted and a list of desirable (~120) ground stations was compiled with the help of users. We developed an algorithm that determined where each ground station was relative to the UVI field of view and then stored a flag for each station in the OST database. The current OST interface allows users to restrict their search by this additional criterion.

With these enhancements completed, we began the main task of developing the image miner algorithms. A key part of this effort was the k-means algorithm developed by Dr. C.-C. Hung at Southern Polytechnic State University under a subcontract to this research program. This algorithm identifies which pixels are within the auroral oval and effectively ignores non-auroral pixels. Once this determination is made, it is possible to use ancillary information to find auroral boundaries, areas, and integrated intensities. Much of this information is stored as a function of local time. In addition, it is possible to estimate how much of the oval is seen within the UVI field of view. This information is also stored in the OST database.

The k-means algorithm, like other algorithms explored for auroral image location, doesn't perform well in the presence of dayglow. Therefore, we decided to build a statistical model of the airglow seen by UVI. We used miner technology developed earlier in the year to examine summer-time UVI images for five years. Based on this we derived a simple analytical form that accurately modeled the airglow seen in LBHL images. (LBHS dayglow is currently being modeled.) Using this model, we could remove airglow then apply the k-means algorithm to the UVI data.

Because of the effort to model the airglow, and the complexity of the image miners, we didn't try to meet our original deadline of completing the miner development in Fall 2002. We are currently planning to complete the miners in Spring 2003. We used the last half of 2002 performing the airglow modeling and refining the image miners. It was during this period that we began to truly appreciate the potential scientific value of the image metadata we were generating. Since this metatdata included total power deposited in the auroral oval and morphological parameters such as cap size and boundary location, it can be used in long-term statistical studies for which high temporal resolution is not necessary. (Recall that data is stored at roughly ten minute intervals.) Furthermore, if higher resolution is required, the miner routines can be used on selected periods at full resolution.

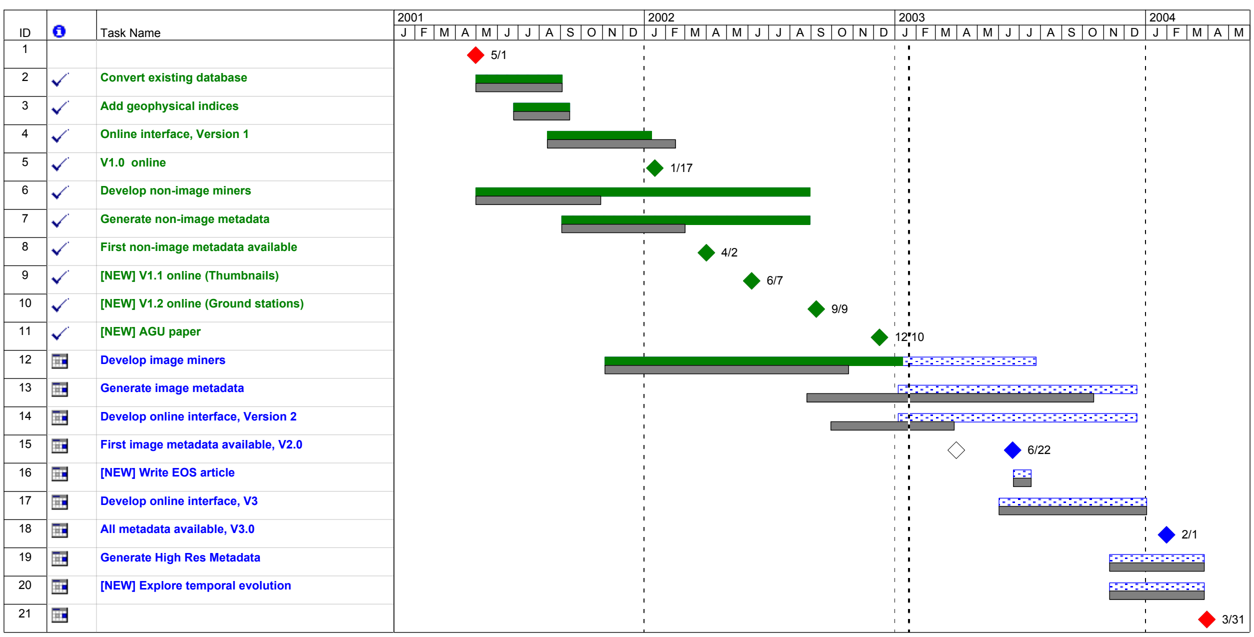
We presented a paper at the Fall AGU that outlined our processing methods, presented our airglow model, and then examined total deposited power as functions of time, local time, activity level, and geophysical indices. The paper was well received. Two, possibly three, new collaborations were formed and data is currently being generated in support of these collaborations.

The table below gives a summary of progress to date compared with the goals and objectives set for this period.

Scheduled Tasks	**Status**
Finish development of image metadata miners.	Completed
Begin processing image metadata.	Delayed to Spring 2003
Develop online interfaces for image metadata.	Delayed to Summer 2003

Additional Tasks	**Status**
Add thumbnail images of the auroral images to the query result, as well as links to the UVI online data products	Completed
Remove background records from the database	Completed
Enable queries based on ground stations	Completed
Fall AGU meeting	Completed

The figure below shows the current project time line. The figure shows the development schedule put forth in the proposal and current estimates of the same. Tasks added to the original proposal tasks have been identified.



Tasks to be carried out in the coming year

The proposal statement of work calls for the second year of effort to be devoted to the following tasks.

- Complete image metadata generation.
- Complete final user interface.
- Process high-resolution metadata.

The final user interface will include the option of searching of the stored image metadata. Time permitting, we will try to store data at a higher temporal resolution for events of special interest to the science community.

In addition, we plan to perform the following new tasks.

- Write EOS article explaining and publicizing OST
- Remove lower priority records from database
- Explore automated methods for studying temporal evolution of auroral forms.

The EOS article is part of our continuing effort to boost awareness of the OST site as a tool for the space science community. Previous efforts have included announcements in the SPA electric newsletter and regular postings to our email list.

The summary above noted how we removed database records that included the background record. While preparing our AGU paper we become aware that there are other situations in which the stored filter is not the most useful filter. The paper focused on the LBHL filter, the only filter combination for which energy deposition can be calculated. However, we encountered other filters in the database, even when an LBHL record was nearby. Therefore, we have decided to rebuild the database again, this time putting priority on LBHL records (and secondary priorities on exposure time and door position).

Also, we have become aware of how useful this technology could be to explore temporal development of substorms. The issue of substorm timing is a critical one that is restricted to event studies because of the lack of automated processing methods. OST was designed to overcome a similar lack in studying UVI images (non-temporal) and is a natural platform for a new investigation. Time-permitting, in the final year of funding we will examine the viability of temporal studies using our miner technology.

Finally, we plan to continue responding to user suggestions to make sure this tool meets the community needs.